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S/170/62/005/010/009/009
B104/B186

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TITLE: Temperature field of a multilayered wall

PERIODICAL: Inzhenerno-fizicheskiy zhurnal, v. 5, no. 10, 1962, 104 - 117

TEXT: If k finite measurement values are available the equation of heat conduction through a multilayered wall is

$$C(r)\frac{\partial t}{\partial \tau}=r^{1-k}\frac{\partial}{\partial r}\left[\lambda(r)r^{k-1}\frac{\partial t}{\partial r}\right] \quad (1.1).$$

The specific heat C and the coefficient of heat conduction λ of this wall depend considerably on the coordinates and are piece-wise continuous functions.

$$\frac{\partial t}{\partial F}=\frac{1}{C(N)N^{k-1}}\frac{\partial}{\partial N}\left[\Lambda(N)N^{k-1}\frac{\partial t}{\partial N}\right] \quad (1.6)$$

is obtained from (1) by introducing the dimensionless coordinate $N = r/r_e$, the Fourier number $F = a_o\tau/r_e^2$, the dimensionless thermal conductivity

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$\Lambda(N) = \lambda(r)/\lambda_o$ and the dimensionless specific heat $C(N) = C(r)a_o\lambda_o$. $t(N_1,F) = t_1(F), \Lambda(N_2)\frac{\partial t(N,E)}{\partial N} = q(F)$ are the mixed boundary conditions. The solution is obtained as a series

$$t(N,F)=t_1(F)1+t_2'(F)\nabla^{-2}1+\ldots+t_1^{(n)}(F)\nabla^{-2n}1+\ldots+$$
$$+q(F)\alpha(N)+q'(F)\nabla^{-2}\alpha+\ldots+q^{(n)}_{(F)}\nabla^{-2n}\alpha+\ldots \quad (2.4)$$

arranged with respect to the derivatives of the quantities to be measured and the radial quasipolynomials of the problem. The function (2.4) describes the temperature field at sufficiently long time values for the initial temperature distribution no longer to influence the heat conduction. The Fourier integral makes it possible to construct the field of the aftereffect of this problem. It can be shown that this field gradually vanishes and that at the initial moment a temperature distribution appears contradicting the initial value of the function (2.4). If the temperatures on the surfaces N_1 and N_2 are known functions of time, then the field of the action can be represented as the sum of the two series:

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$$t(N,\ F) = \sum_{n=0}^{\infty} t_1^{(n)}(F) P_n(N,\ N_1) + t_2^{(n)}(F) P_n(N,\ N_2), \qquad (3.3).$$

The series are arranged accordingly with respect to the derivatives of the temperatures to be measured and with respect to the radial quasipolynomials of the problem. The convective heat exchange with media at variable temperatures is studied with the aid of the boundary conditions

$$[t_i(F) - t(N_i,\ F)]\, B_i = -\Lambda(N_i)\frac{\partial t(N_i,\ F)}{\partial N} \qquad (4.1)$$

$$[t(N_e,\ F) - t_e(F)]\, B_e = -\Lambda(N_e)\frac{\partial}{\partial N} t(N_e,\ F) \qquad (4.2).$$

of the third kind. For the field of action

$$t(N,\ F) = t_i(F) P_0(N,\ N_i) + t_i'(F) P_1(N,\ N_i) + \ldots + t_i^{(n)}(F) P_n(N,\ N_i) + \ldots$$
$$+ t_e(F) P_0(N,\ N_e) + t_e'(F) P_1(N,\ N_e) + \ldots + t_e^{(n)}(F) P_n(N,\ N_e) + \ldots, \quad (4.4)$$

is obtained in a similar way. This series is arranged with respect to the

derivatives of the temperatures of the inner and outer medium. If the temperature on the inner surface is kept constant, and if the temperature on the outer surface varies periodically, then

$$t(N,\ F) = t_i P_0(N,\ N_i) +$$
$$+ t_0 [P_0(N,\ N_e) - \omega^2 P_2(N,\ N_e) + \omega^4 P_4(N,\ N_e) - \ldots] \cos \omega F +$$
$$+ t_0 [-\omega P_1(N,\ N_e) + \omega^3 P_3(N,\ N_e) - \omega^5 P_5(N,\ N_e) + \ldots] \sin \omega F, \quad (5.20)$$

is valid for the field of action.

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SUBMITTED: July 23, 1962